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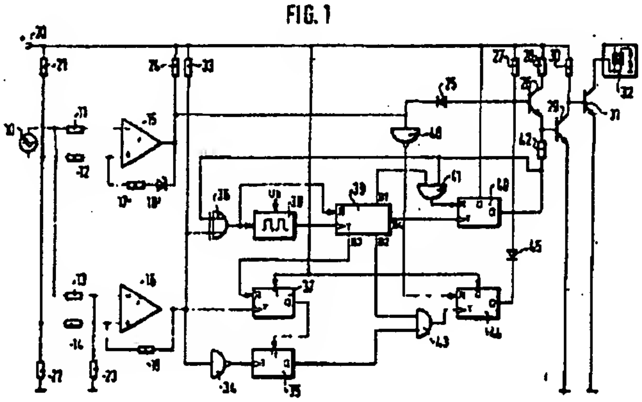
(54) Dwell and rest coil current control in IC engine ignition units

(57) An ignition unit for internal combustion engines is proposed, having a first threshold switch (15) controlled by the voltage of an inductive angle of rotation transmitter, the make and break threshold values of the switch essentially controlling the current flow time in an ignition coil (32). A second, correspondingly controlled threshold switch (16) having the same make threshold as switch (15) but having a positive break threshold value (Ua_2) triggers, on reaching the said threshold value, a time-function element, constructed as a digital counter (39), in which a clock frequency (38) is counted cyclically. On expiration of the hold time of the time-function element, if the first switch has not initiated the spark, the ignition coil current is switched off via a bistable switching stage (40) so as to switch off the rest current. The ignition coil current is switched on again via a logic interconnection circuit (41) if the bistable switching stage (40) is in the switched-off state and at the same time a lower numerical value is reached in th counter (39). This produces a reduction of the dwell angle at low speeds, with the angle of rotation transmitter (10) otherwise functioning normally. Both functions are essentially achieved by means of a single counter (39).

FIG. 1



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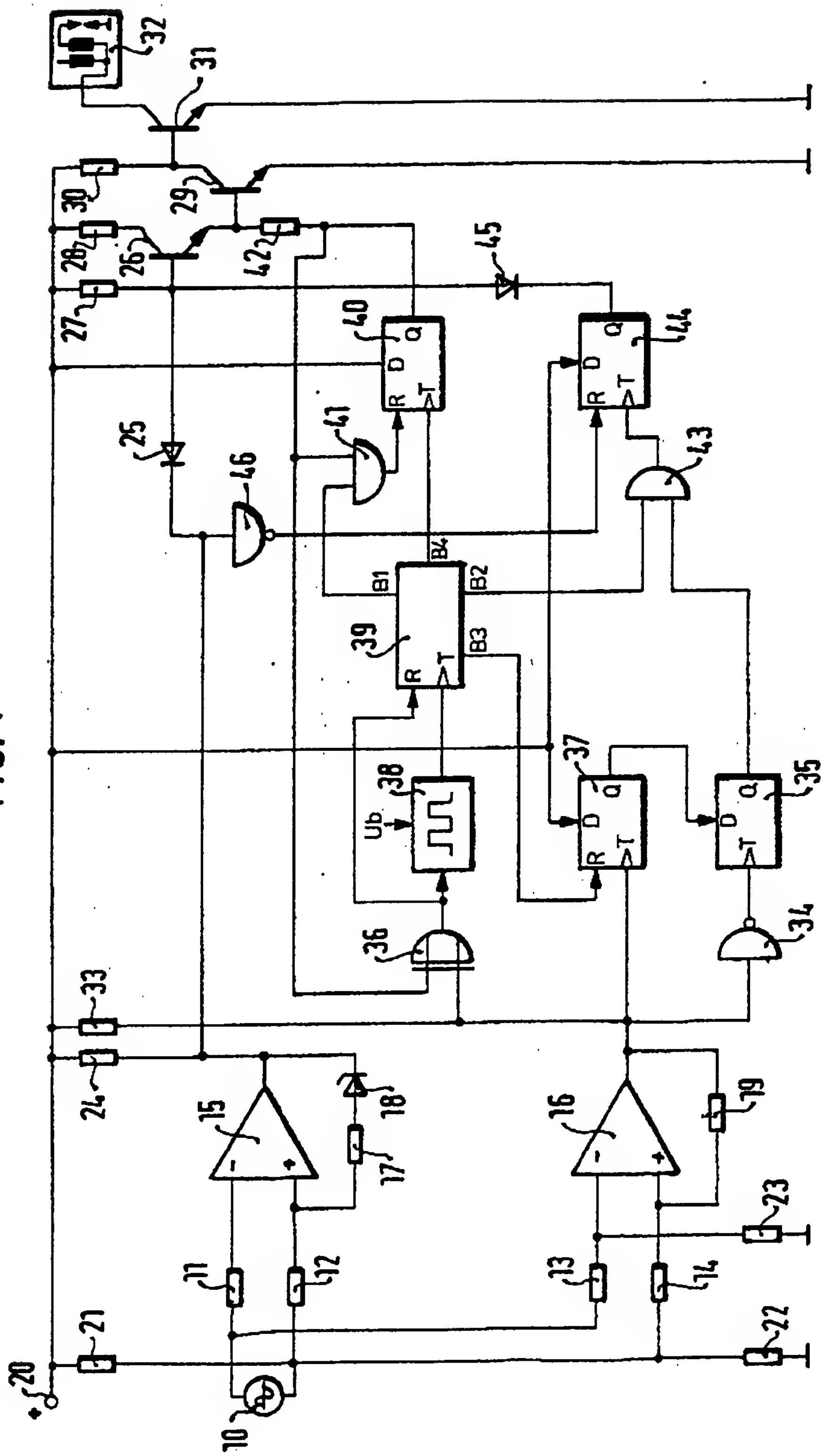


FIG. 1

FIG. 2

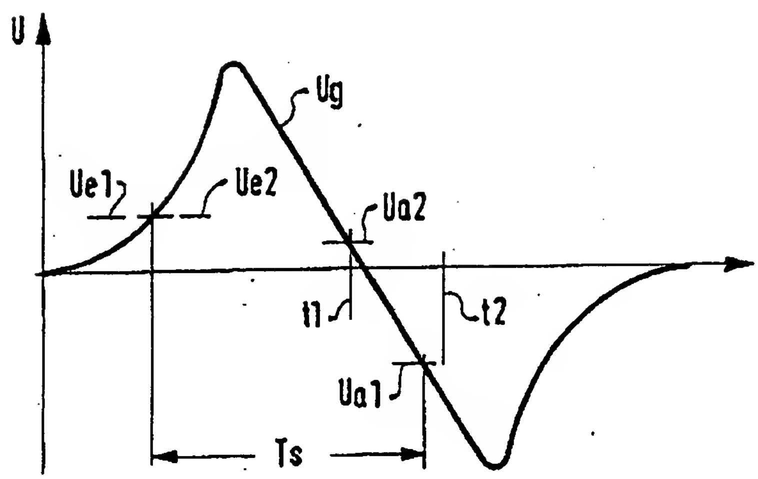


FIG. 4

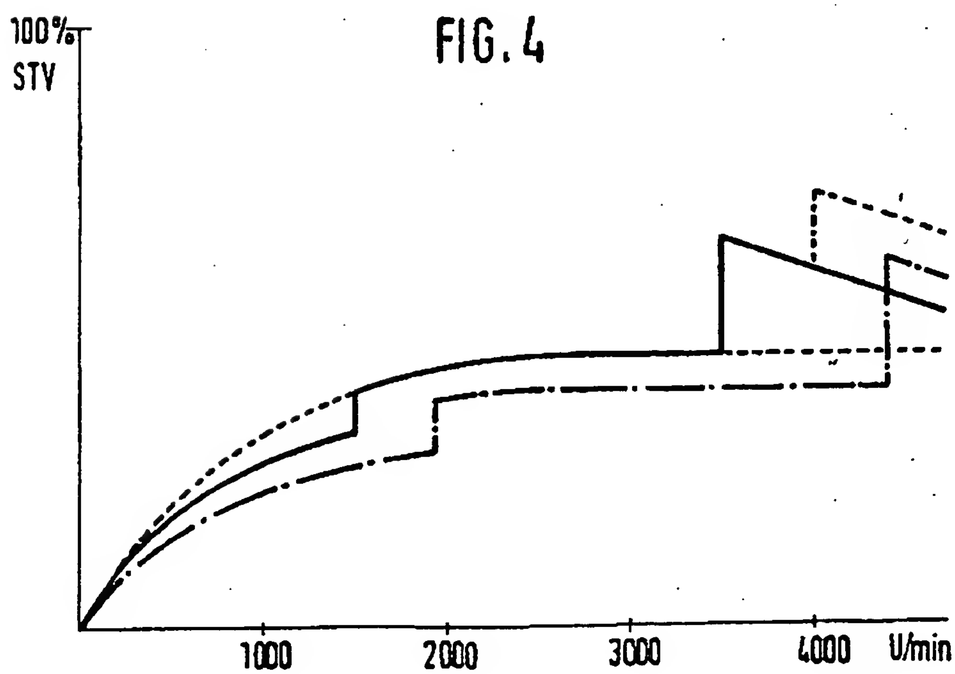
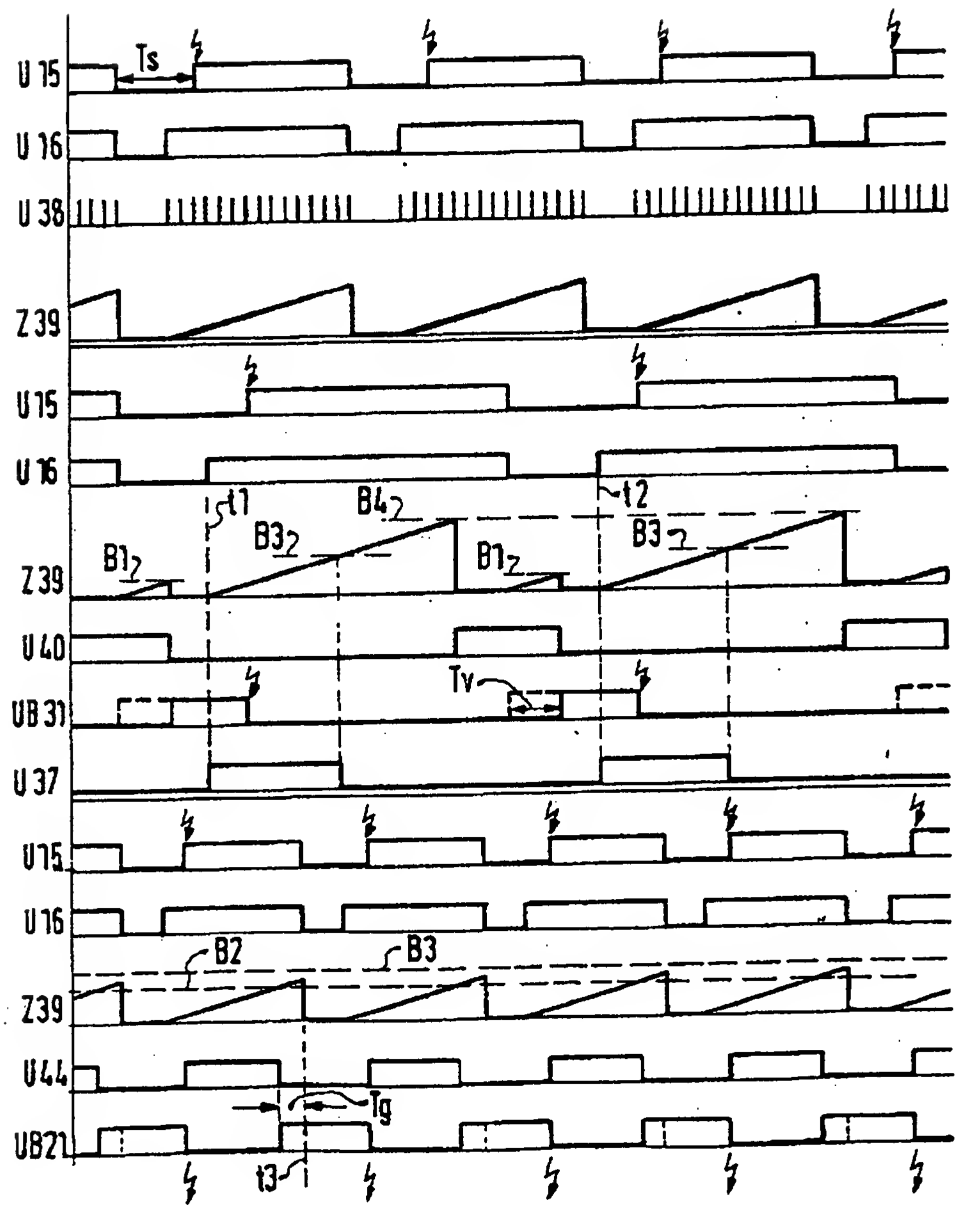


FIG. 3


U 15
Ts
U 16
U 38
Z 39
U 15
U 16
Z 39
t1
B4
B3
B1
B1
t2
B3
U 40
UB 31
Tv
U 37
U 15
U 16
Z 39
B2
B3
U 44
UB 21
Tg
t3

SPECIFICATION

Ignition unit for internal combustion engines

State of the art

The invention starts from en ignition unit for Internal combustion englnes according to the generic clause of the main claim. German Offenlegungsschrift 3,215,728 has already disclosed such an ignition unit, in which the time-function element, triggered by the second threshold switch, serves to switch off the rest current, i.e. at the end of the hold time of this time-function element the ignition coil current is switched off, thereby avoiding overheating of the ignition coil and unnecessary power loss. This switching off can above ell become necessary when, due to stalling of the internal combustion engine, the ignition unit switched on but the internal combustion engine not In operation, end at very low speed, the break value of the first threshold switch is not reached.

The known circuit is en analogue circuit which exclusively serves to switch off the rest current; this requires a not insubstantial expense end moreover is difficult to integrate in the time-function element due to the capacitor.

Advantages of the invention

Against this, the ignition unit according to the invention, heving the characterising features of the main claim, has the advantage that as a result of the purely digital solution the circuit can easily be integrated and in particular can be realised in a microcomputer. In addition, the time-function element, reelised as a digital counter, is also used for reducing the dwell angle at low speeds without requlring substantial additional expenditure on the circuitry.

The measures set out in the sub-claims permit edvantegeous further developments and improvements of the ignition unit specified in the main claim. A particularly edventageous feeture is the additional use of the time-function element, or of the speed information obtained through the time-function element, to increase the dwell angle at high speeds. As a result, the counter employed as the time-function element is used in three ways without requiring substantial or expensive additional circuitry.

Moreover, it is particularly advantageous to control the clock frequency for the counter as a function of the supply voltage. This has the effect that the dwell angle Is adapt d in the functionally correct manner vla the speed end the battery voltage in order on the one hand to evoid power losses at low speeds and on the other hand to ensure a sufficient dwell angle at higher speeds.

Drawing

An illustrative embodiment of the invention is depicted in the drawing and expleined in more detail in the description which follows. Fig. 1 shows e circuit construction of the illustrative embodiment, Fig. 2 shows a signal diagram to explain the make and break actions of the two threshold switches as a function of the transmitter voltage, Fig. 3 shows a signel diagram to explain the mode of action of the circuit and Fig. 4 shows e signal diagram to represent the dwell angle function.

Description of the illustrative embodiment

The two connections of en inductive angle of rotation transmitter 10, which is driven by the camsheft or cranksheft of an Internal combustion engine, are each connected vie two resistences 11, 12 and 13, 14 respectively, with the inverting and non-inverting input of two operation amplifiers connected es threshold switches 15, 16. The first threshold switch 15 is feedback-coupled vla the series connectlon of a resistance 17 with a Z-diode 18 to the non-inverting input, whilst the second threshold switch 16 is correspondingly feedback-coupled via a reslstance 19. A supply voltage source 20 ls connected to earth via a voltage divider consisting of two resistances 21, 22. The tapping between the two resistances 21, 22 is connected to the link point between the angle of rotation transmitter 10 and the resistances 14 and 12. The Inverting input of the second threshold switch 16 Is connected to eerth via a resistance 23.

The clrcuit, described ebove, of the two threshold switches with the inductive angle of rotatlon trensmitter 10 essentially corresponds to the circuit mentioned at the outset as being the state of the art. In the letter, there are specified additional components for purposes of safety, interference protection and voltage stabilisation, but these have been omitted, for simplicity, in the present circuit. They can of course also be employed edventageously In the present case.

The output of the first threshold switch 15 is connected both via a resistance 24 to the supply voltage source 20, and via the cathode-anode section of a diode 25 to the base of a first driving transistor 26. Its base and collector are each connected to the supply voltag source 20 vie a resistance 27, 28. The emitter of this transistor 26 is connected to earth via the base emitter section of a second transistor 29. The collector of this transistor 29 is connected vie e resistance 30 to the supply voltage source 20, and is also directly connect d to the base of e final-stage transistor 31. The emitter of the final-stag transistor 31, the latter being preferably constructed as a Darlington transistor, is connected to earth and its collector is connected in e known manner to an ignition coil arrange-

ment 32. Such en ignition coil arrangement 32 supplies sparking pluga with high voltage ignition signals, again In a known manner.

The output of the second threshold switch 16 is connected via a resistence 33 to the supply voltage source 20, via an inverter 34 to the clock input T of a D-flip-flop 35 and finally to an input of an antivelence gate (EXOR) 36 and with the clock input T of a further D-flip-flop 37. The output of the antivalence gate 36 switches e clock frequency generator 38 on and off and resets e counter 39 via e reset input R. The clock frequency of the clock frequency generator 38 is set and controlled as a function of the supply voltage Ub. The clock frequency of the clock frequency generator 38 is fed to the clock input T of the counter 39. The latter has four switch outputs, on which, respectively, e signal is produced when the corresponding numerical values B1 to B4 are reached. The switch output allocated to the numerical value B3 is connected to the reset input R of the flipflop 37, whose output Q is connected to the D-input of the flipflop 35. The switch output of the counter 39 allocated to the numerical value B4 is connected to the clock input T of a further D-flipflop 40, whose output Q Is connected to the second input of the antivalence gate 36, to an input of an AND-gate 41 and vie e resistence 42 to the base of the trensistor 29. The switch output of the counter 39 allocated to the numericel value B1 is connected to the second input of the AND-gate 41, whose output is connected to the reset input of the flipflop 40. The switch output of the counter 39 allocated to the numerical value B2 is connected via en AND-gate 43 to the clock input T of a further D-flipflop 44, whose inverting output Q is connected via the cathode-anode section of e diode 45 to the base of the transistor 26. The output Q of the flipflop 35 is connected to the second input of the AND-gete 43. The output of the first threshold switch 15 is connected via an inverter 46 to the reset input R of the flipflop 44. Finally, the D-inputs of the flipflops 37, 40, 44 are connected to the supply voltage aource 20.

The signal diagram shown in Fig. 2 depicts the variation of the transmitter voltage Ug of the angle of rotation transmltter 10 as a function of time. Since both threshold switches 15, 16 have the same make threshold valu Ue_1 end Ue_2 respectiv ly, they make conjointly, i.e. thelr output changes from a 1-signal to an O-signal. The second threshold switch 16 has a positive end hence earlier break threshold value Ua_2, whilst the threshold switch 15 has a negative and henc later break value Ua_1. The breaking of the threshold switches correspondingly results in e signal chenge, on the output sid , from an O-signal to a 1-signal. Th different make and break threshold valu s ere achieved through the feedback branches 17, 18, and 19 and the input wiring of the threshold switches 15, 16. In the normal case, i.e. at medium speeds, tha dwell time Ts, i.e. the duration of current flow in the primery winding of the ignition coil, is determined by the threshold switch 15. i.e. the end of the dwall time Ts, determines tha ignition time. On reaching the breek threshold value Ua_2 of the second threshold switch 16, the time-function element formed by the clock frequency generator 18 and the counter 39 is triggered at time t1. At the end of tha hold time of this time-function element, the current flow on the primary side is switched off at time t2 (in the normal case this has already occurred), and this serves both to switch off the rest current end also, at very low speeds, to cause the emergency triggering of the ignition, namely if the threshold value Ua_1 is not reached when the signel level is too low.

The mode of operation end interaction of the threshold values–as depicted in Fig. 2–is already known per se from the prior art referred to at the outset.

To explain the mode of action, three cases will be considared in Fig. 3. First, a medium speed of the internal combustion engine of, for example, 2,000 to 3,000 revolutions per minute will be essumed. The generation of the two output signels U15 end U16 of the two threshold switches 15 and 16 has already been explained in connection with Fig. 2. When the threshold switch 16 breaks, i.a. when its output changes from e O-signal to a 1-signal, there is created, during this 1-signal, a 1-signal at the output of the antivalence gate 36 (the other output of the antivalence gate receiving a O-signal), through which the clock frequency generator 38 is switched on. Its clock signals U38 ere then counted forward (Z39) in the counter 39. At the next trailing edge of a signal U16, the counter 39 is reset again. The medium speed is so defined thet the final count is between the numerical values B3 end B4. Since the numerical value B4 Is not reached, the flipflop 40 remains reset and does not exart eny ection. As will be shown in more deteil later, tha output of the flipflop 35, is, et this speed, also constantly at a O-signal, so that the flipflop 44 is elso without action. Accordingly, in this speed range the current flow time through the ignition coil 32, i.e. the dwell time, is determined exclusively by the comparator 15 or its output aignal sequence U15.

We shall next consider the mode of action et a low speed. A low speed can be essumed to apply when, for exempl , the speed is less than 2,000 rpm or less than 1,500 rpm. This limiting speed is determlned by the numarical value B4. In Fig. 3, th case f the low speed is depicted by the fifth to tenth signel sequence. Because of the low speed, the counter 39 now reaches the numerical value B4,

as a result of which a 1-signal is generated at the corresponding switch output, and this signal sets the flipflop 40. The output signal U40 of the latter has the effect that the counter 39 is reset via the antivalence gate 36. If now the output of the threshold switch 16 changes to a 0-signal, there is still superposed, on the output of the flipflop 40, a 1-signal at an input of this antivalence gate 36, so that the counter 39 starts a new counting sequence. When the numerical value B1 is reached, the flipflop 40 is reset via the AND-gate 41, so that the transistor 29 can now go into the offstate and the current flow via the transistor 31 is released. The counter 39 is now again reset via the antivalence gate 36 and starts to count afresh as from the next leading edge of a signal U16. The numerical value B1 accordingly predetermines the time Tv by which the switching on of the ignition coil current is delayed. Accordingly, at low speeds the dwell angle is reduced, resulting in an effective reduction of the power loss occurring in this range. Fig. 4 shows this dwell angle jump at 1,500 rpm (continuous curve). The broken line shows the conditions which would prevail without this dwell angle reduction. Fig. 4 shows the dependence of the control pulse-duty factor STV of the control signal sequence for the final-stage transistor 31, as a function of the speed.

The reaching of the numerical value B4 however at the same time represents the end of the hold time (t2) of the time-function element which was started at time t1 and consists of the components 38, 39. If, for one of the reasons mentioned at the outset, the break threshold value Ua_1 of the threshold contact 15 should not have been reached or if this threshold contact should not have cut out for some other reason, the current flow in the ignition coil 32 would continue, without creating an ignition spark. However, at time t2 the setting of the flipflop 40 produces a 1-signal on the base of the transistor 29, by which the transistor 31 is blocked and hence the current flow is interrupted. With the internal combustion engine static, this has the effect of switching off the rest current, whilst at low speeds it assists by creating an ignition spark. As a result of the positive break threshold value Ua_2, a triggering of the time-function element 38, 39 is ensured in every case if the internal combustion engine is static.

Both at medium and at low speeds, the numerical value B3 is regularly exceeded in the counter 39. The flipflop 37, which is in each case set with a leading edge of a signal U16, is as a result regularly reset via the counter 39 on reaching the numerical value B3. This cr ates the signal sequence U37 on the output side. Since for each trailing edge of a signal U16 the output signal of the flipflop 37 is accepted in the flipflop 35 through the inverter 34 (this signal always being zero at this point in time), the output signal of the flipflop 35 always remains at zero, so that the AND-gate 43 remains blocked. The flipflop 44 thus remains without action at low and medium speeds.

Finally, it is still necessary to consider the case of high speeds, for example of above 3,000 rpm, which is represented by the signal sequences 11 to 15 in Fig. 3. At these higher speeds the numerical value B3, which predetermines this limiting speed, is not reached, so that the flipflop 37 can no longer be reset. The 1-signal, which thus is constantly present on the output side, accordingly also produces a constantly present 1-signal at the output of the flipflop 35, so that the AND-gate 43 is opened for signals at the output B2 of the counter 39. Now, each time this numerical value B2 is reached in the counter 39, the flipflop 44 is set (0-signal at the inverting output) and is reset with leading edges of the signal sequence U15 (1-signal at the inverting output). The signal sequence U44 thus produced at the output of the flipflop 44 acts on the base of the transistor 26 in such a manner that during a 0-signal at the output of the flipflop 44 the transistor 26 remains blocked under all circumstances, regardless of what signal is present at the output of the threshold switch 15. The blocking of the transistor 26 again causes current to flow through the ignition coil 32. Since without the flipflop 44 this current flow would only start at time t3, the flipflop 44 results in an increase in dwell angle by an amount Tg at higher speeds. In Fig. 4, this increase in dwell angle is represented by a jump in the continuous curve at 3,000 rpm.

Of course instead of a single-stage increase of dwell angle at a higher speed, there may be employed a plurality of steps at different speeds. This is represented by the dotted line in Fig. 4. Using the same counter 39 it would be necessary, for each additional jump in dwell angle, to provide, instead of the two switch outputs B2, B3, two additional switch outputs B5, B6 by which a circuit corresponding to the circuit 34, 35, 37, 43 is driven. If thus a plurality of steps and hence a plurality of AND-gates 43 are present, their outputs would have to be fed via an OR-interconnection to the clock input of the flipflop 44. Accordingly, it is possible in a simple manner, i.e. with few and cheap components, to effect the dwell angle increas at high speeds in as finely graduated a manner as desired.

It should be pointed out again that by means of a single counter 39 in the time-function element 38, 39 it is possible to achiev both switching off of the rest current as well as auxili ry ignition at low speeds or in the event of faults, reduction of the dw ll angle at low speeds and increas of the dwell angl at high speeds. For this purpose, a relatively simple and cheap additional circuitry

of th counter 39 is needed.

The dash-dot line depicted in Fig. 4 shows the conditions at a higher supply voltage (for example a more highly charged battery). This shift in the curve is achieved through the clock frequency of the clock frequency generator 38 being controlled as a function of the supply voltage Ub. As a result, the numerical values B1 to B4 are reached at different times, so that the regions of the jumps in the control pulse-duty ratio shift and are adapted in the functionally correct manner both via the speed and via the battery voltage. Moreover, the switching off of the rest current takes place functionally correctly, i.e. earlier with the increasing supply voltage.

To produce the circuit it is possible to use, for example, component 74 C 161 for the counter 39 and, for example, the commercially available component 4013 (for example Motorola, National) for the flipflops

CLAIMS

1. Ignition unit for internal combustion engines, having a first threshold switch (15) controlled by the voltage of an inductive angle of rotation transmitter (10), the make and break threshold values of which switch essentially control the current flow time in an ignition coil (32), and having a second, correspondingly controlled threshold switch with positive break threshold value, on reaching of which a time-function element (38, 39) can be triggered, said element switching off the ignition coil current when the hold time of the element has expired, characterised in that the time-function element (38, 39) is constructed as a counter in which a clock frequency is counted cyclically, and on reaching a predeterminable numerical value (B4) the ignition coil current is switched off via a first switching state of a bistable switching stage (40), there also being a logic interconnection circuit (41) by means of which, if the first switching state applies and at the same time a second, lower numerical value (B1) is reached in the counter (39), the Ignition coil current is switched on.

2. Ignition unit according to Claim 1, characterised in that the switching on of the ignition coil current can be controlled via the second switching state of the bi-stable switching stage (40).

3. Ignition unit according to Claim 1 or 2, characterised in that the switching on of the clock frequency and the resetting of the counter (39) takes place via a gate arrangement (for example an EXOR-gate) only if either the first switching state of the bistable switching stage or the break state of the second threshold switch applies.

4. Ignition unit according to on of the preceding claims, characterised in that, through an increase in dwell angle if a numerical value (B3), corresponding to a higher speed, is not reached in th counter (39), a bistable switching stage (44) can be switched on, through which, on reaching a predeterminable further numerical value (b2) in the counter (39), the flow of current in the ignition coil can be switched on (start of dwell time).

5. Ignition unit according to Claim 4, characterised in that for switching on the bistable switching stage (44) an additional bistable switching arrangement (34, 35, 37), which can be brought into a first switching state by means of the second threshold switch, is provided, the second switching state of which being inserted (sic) if the numerical value (B3) corresponding to the higher speed is not reached in the counter (39).

6. Ignition unit according to Claim 5, characterised in that the bistable switching arrangement consists of two bistable switching stages (35, 37) which are set by different signal edges of the second threshold switch (16), the first switching stage (37) being resettable when the numerical value corresponding to the higher speed is reached in the countar (39) and the output signal of this first switching stage (37) being transferable to the second switching stage (35) on occurence of a setting signal.

7. Ignition unit according to Claim 4, characterised in that the bistable switching stage (44) is resettable by ignition signals (end of dwell time).

8. Ignition unit according to one of the preceding claims, characterised in that in order to influence the time for which current flows, the outputs of the bistable switching stage (40, 44) are connected to the base of a driving transistor which is connected, for controlling the ignition coil current, in front of a final-stage transistor (31).

9. Ignition unit according to one of the preceding claims, characterised in that the clock frequency can be set as a function of the supply voltage (Ub).

10. An ignition unit substantially as herein described with reference to the accompanying drawings.

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